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June 2016

Working Paper

SERIES 2016:33

THE VARIETIES OF DEMOCRACY INSTITUTE



UNIVERSITY OF GOTHENBURG
DEPT OF POLITICAL SCIENCE

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Sequential Requisites Analysis: A New Method for Analyzing Sequential Relationships in Ordinal Data*

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* This research project was supported by Riksbankens Jubileumsfond, Grant M13-0559:1, PI: Staffan I. Lindberg, V-Dem Institute, University of Gothenburg, Sweden; by Swedish Research Council, Grant C0556201, PIs: Staffan I. Lindberg, V-Dem Institute, University of Gothenburg, Sweden and Jan Teorell, Department of Political Science, Lund University, Sweden; by Knut and Alice Wallenberg Foundation to Wallenberg Academy Fellow Staffan I. Lindberg, Grant 2013.0166, V-Dem Institute, University of Gothenburg, Sweden; as well as by internal grants from the Vice-Chancellor's office, the Dean of the College of Social Sciences, and the Department of Political Science at University of Gothenburg. We performed simulations and other computational tasks using resources provided by the Notre Dame Center for Research Computing (CRC) through the High Performance Computing section and the Swedish National Infrastructure for Computing (SNIC) at the National Supercomputer Centre in Sweden. We specifically acknowledge the assistance of In-Saeng Suh at CRC and Johan Raber at SNIC in facilitating our use of their respective systems.

Abstract

This paper presents a new method inspired by evolutionary biology for analyzing longer sequences of requisites for the emergence of particular outcome variables across numerous combinations of ordinal variables in social science analysis. The approach involves repeated pairwise investigations of states in a set of variables and identifying what states in the variables that occur before states in all other variables. We illustrate the proposed method by analyzing a set of variables from version 6 of the V-Dem dataset (Coppedge et al. 2015a, b). With a large set of indicators measured over many years, the method makes it possible to explore long, complex sequences across many variables in quantitative datasets. This affords an opportunity, for example, to disentangle the sequential requisites of failing and successful sequences in democratization. For policy purposes this is instrumental: Which components of democracy are most exogenous and least endogenous and therefore the ideal targets for democracy promotion at different stages?

1. Introduction

Sequences are critical to understanding many social processes such as regime transitions, onset of civil wars, economic development, and institutional development. The subject of specific concern to us that has important policy-implications is the study of democratization. This is a field of study endowed with persuasive theorists and accomplished area experts (e.g. Dahl 1971, Diamond *et al* 1988, Linz *et al* 1996, O'Donnell *et al* 1986, Schedler 2013). They provide us with abundant lessons from both detailed country case-studies and comparative analyses. Large-N datasets on democracy and democratization emerged already in the 1960s with the purpose of evaluating more general hypotheses. The field has since seen substantial increasing methodological sophistication (e.g. Acemoglu *et al.* 2001, Bollen 1993, Inglehart *et al* 2005, Jackman 1973, Norris 2008, Lipset 1959, Przeworski *et al* 2000), but has also become crowded with typologies depicting various semi-authoritarian regimes (e.g. Gandhi *et al* 2007; Geddes 1999; Levitsky *et al* 2002), democratic regimes (e.g., Lijphart 1999), innumerable subtypes (Collier *et al* 1997), and full typologies from autocratic to democratic regimes (e.g. Diamond 2002).

A core issue remains, however. Existing studies habitually provide evidence on variables related to democratization (e.g. Acemoglu *et al* 2005, Boix 2003, Coppedge 2012, Przeworski 1991, Teorell 2010) from which causal inferences are attempted. Yet, we have been unable to use large-N data to depict the series of requisite conditions that are typical for countries making their way from one regime to another. We “know” that processes of democratization are messy with many factors interacting over time that eventually produce either good or less good outcomes. However, we have been unable to both measure all those aspects systematically across the world and along extended time spans, and even less able to systematically analyze the many sequential and interrelated changes among those variables. The Varieties of Democracy (V-Dem) dataset has solved the first issue providing data on over 350 variables across 173 countries and the period from 1900 to 2012 (Coppedge *et al.* 2015a, b). A first effort at solving the second issue was presented in Lindenfors *et al.* (2015). The present paper takes that framework significantly further and presents what we believe to be a viable solution to the second problem.

2. On the State of the Field of Democratization

One subset of scholars have focused on which variables *external* to the political system that may increase the probability of democratization, such as geography, modernization, colonialism, inequality, and societal/class conflict. Lipset's milestone (1959) sparked a long deliberation on whether, or to what extent, economic development, or more broadly modernization, affects democratization and democratic consolidation (Acemoglu *et al* 2009; Bollen 1983; Burkhart *et al* 1994; Huntington 1991; Knutsen *et al* 2015; Przeworski *et al* 1997). Yet, the field seems not to have produced a definitive answer to the question if economic development is beneficial for democratic stability but not transitions (Przeworski *et al.* 2000); if it facilitates neither transitions nor stability (Acemoglu *et al.* 2009); or that it furthers both of them (Boix 2003).

Another group focuses on research on *endogenous* dynamics of democratization. These are studies analyzing how parts of what we think of as a democratic regime, or autocracy, affect each other in positive or negative ways. Much of the early writing took “big” approaches to democratizations. For example, Rustow's (1970) timeless piece suggested four inter-related stages of democratization: national unity, prolonged political struggle, deliberate accords, and habituation to democratic rules (c.f. Carothers 2002). O'Donnell *et al* (1986) finds that democratization is more likely when a bargaining between moderate actors (“soft-liners”) on both sides precedes a “founding” election and projected four transition processes with varying outcomes. Linz *et al* (1996: 57-60) argue instead that there are six alternative pathways of democratic transitions, each with different consequences for democratic consolidation (see also Karl 1990; Munck *et al* 1997.)

More recently, many scholars have taken a more disaggregated approach and looking at specific aspects rather than entire processes of democratization, thus identifying something narrower than “democracy” as their dependent variable. These works are typically associated with more restricted claims, like if individual rights and institutional checks and balances go before mass suffrage, democracy has a higher probability of enduring (Berlin 2002), or that repeated elections – even if not entirely free and fair – are instrumental to spur and sustain processes of expanding civil liberties (Howard *et al* 2006; Lindberg (2006). Again, we find contradictory results such that elections can be a constituent and stabilizing component of dictatorship (e.g. Gandhi *et al* 2007). The literature on the role of civil society has produced more coherent results generally viewing the mobilization of civil society as critical to the breakdown of authoritarianism and good for democratic consolidation (Bernhard 1993; Bunce 2010; Ekiert *et al* 1999; O'Donnell *et al* 1986; Putnam 1993), even if it has also been argued that a civil society conveying the interests of society to the regime may promote authoritarian

stability (Gandhi 2010, Magaloni 2008). The role of political parties suggests that where parties are poorly institutionalized electoral regimes are likely to lack stability (Bernhard *et al* 2015; Hicken *et al* 2011; Roberts *et al* 1999).

Thus, a great deal of work in political science seeks to investigate the order of events or utilizes historical process tracing of complex sequential relationships to explain political outcomes such as democratization. The sequences of complex social processes usually involve hundreds of related variables with a large number of characteristics, and today's standard techniques for time-series, cross-sectional (TSCS) analysis for observational panel-data, are not very apt for this sort of problems. First, they do not solve the causal inference problem to a greater or lesser degree than the approach suggested here below. Second, they typically force analysts to make very strong assumptions about invariant time-distance between x and y in terms of which lag should be used. Third, they are designed for giving insights into the average effect of x_i on y given the conditions z_i , sometimes taking interaction effects into account. However, the social and political processes that we as social scientists are typically interested in, such as democratization, are rarely even approximations of such simplifications. Rather, complex and often long series of sequentially related variables are in play and contribute to the outcome.

Finally, large-N research on sequences in political science has been hampered by the lack of appropriate data. The quality, conceptual validity, and reliability of the extant sources on democracy are discussed by others (e.g. Coppedge *et al.* 2015). For sequential analysis of democratization, one needs long time series covering as many countries as possible. This makes sources like BNR index (Bernhard *et al.* 2001), Bertelsmann Transformation Index (Bertelsmann Foundation), the European Intelligence Unit's index (EIU 2010), the Democracy Barometer (Bühlmann *et al.* 2012), and the World Governance Indicators (Kaufmann 2010) less useful. The remaining sources all suffer from being highly aggregated and lacking detailed measures of individual aspects of democracy that can be used for sequential analysis, including Freedom House's political rights and civil liberties ratings (freedomhouse.org), Polity IV's democracy and autocracy scores and their components (Marshall *et al.* 2014), the Unified Democracy Scores (Pemstein *et al.* 2010), the democracy-dictatorship index (Alvarez *et al.* 1996; Cheibub *et al.* 2010), the Lexical index of electoral democracy (Skaaning *et al.* 2015), the Competition and Participation indices developed by Tatu Vanhanen (2000), the BMR index (Boix *et al.* 2013), and the Contestation and Inclusiveness indices (Coppedge *et al.* 2008). In effect, researchers have only had highly aggregated indices of democracy to draw upon, and since there have been no appropriate methods developed for analysis of time-variant, sequential

relationships across many variables, it has never been possible to test propositions about more specific relationships in a systematic and comprehensive fashion.

3. Sequence Analysis of Ordinal Data Customized from Evolutionary Biology

We suggest here a new method – the sequential requisites analysis – to enable delineation and testing of long series of requisites involving many variables, while capitalizing on V-Dem’s multidimensional understanding of democracy and provision of over 350 highly disaggregated measures of various aspects of democracy for 173 countries from 1900 to 2012. This combination of the new data and a new method inspired by evolutionary biology offers an opportunity to evaluate existing theories of failing and successful sequences of democratization in the most rigorous fashion possible taking full advantage of the complete universe of available data. Perhaps even more significant, unexplored and under-theorized chains of sequential requisites can be investigated with this method. The method we describe here makes it possible to search for sequences not necessarily contemplated by current theory – and do so with regards to long chains of sequential relationships between many factors.

This is a form of descriptive, basic research whose importance should not be underestimated. Description has led to groundbreaking advances across many sciences, including evolutionary biology from which we adapt methodological approaches. Simply put, we do not know the answers yet to relatively simple questions like: When a country transitions from autocracy to democracy (or vice versa), which elements come first? Which are the common patterns, a finite set of sequences for sequences that are failing to lead to democracy, and those that result in democratization?

With a large set of indicators measured over many years, it would become possible for the first time to explore transition sequences.¹ It is quite possible, maybe even probable, that there are varying paths – sequences of conditional relationships – to each of them. This affords an opportunity to disentangle the sequential requisites of failing and successful sequences in democratization. For policy purposes this is also instrumental: Which components of democracy are most exogenous (affecting other components) and least endogenous (dependent

¹ Sequencing is explored by Schneider *et al* (2004) and Wilson (2014, 2015) with a smaller set of indicators and/or a shorter stretch of time. See also McFaul (2005) and Möller *et al* (2010).

on other components) and therefore the ideal targets for democracy promotion at different stages?

Elsewhere, we have suggested a set of methods to identify sequences within a set of variables (Lindenfors et al. 2015). There exist a number of approaches to identify sequences in ordinal and categorical time series data, many more or less inspired by evolutionary biology. Noteworthy are e.g. social sequence analyses that are inspired by DNA sequence analyses (e.g. Abbott 1995; Abbot & Tsay 2000, Gauthier et al. 2010, Casper and Wilson 2015), set theoretic approaches such as qualitative comparative analysis (QCA) (Ragin 1987; Rihoux & Ragin 2009), and time-series cross-section methods (Beck 2008). There also exists a more novel approach using Bayesian modelling to construe dynamic systems indicating flow of change (Ranganathan et al. 2014; Spaiser et al. 2014). As mentioned before, we have also suggested a number of methods, graphical and analytical (Lindenfors et al. 2015). All these methods have their pros and cons, where method choice is dependent on the format of the data and the specific question of interest. The method presented here sits comfortably in the set-theoretic tradition (see e.g. Paine 2016; Thiem et al. 2016; Schneider 2016 for discussions on these methods), though we would like to shy away from inferring causation and instead focus on the method's ability to describe historical pathways.

Analyses based on the approach proposed below can in principle be conducted for qualitative data measured at any level (interval, ordinal, binary) but in practice, it requires ordinal or binary variables in order to be easily interpretable. The analysis is also easier to interpret if all variables in a particular analysis have the same level of measurement, but this is not required. From the analysis, combining a series of bivariate analyses (by running all variables against all), one can establish long series of sequences involving many multi-state variables. The result is a detailed and empirically based “map” of which aspects of a phenomenon that tends to occur before other aspects. In other words, we are now capable of providing the first solution to presenting detailed sequences of democratization and other similar phenomena. Also, the requisite analysis presented below promises us to be in a much better position to answer prescriptive questions with a strong empirical foundation.

Here we present an extended requisite analysis to identify historically realized sequences of events between states of variables. We suggest that the approach detailed below can establish descriptive sequences in terms of conditions among, in principle, an unlimited number of multi-state ordinal variables over any stretch of time, given that adequate data is available and that there are, in fact, sequential relationships to be found. To the extent that one can establish that any one sequence across time and space always, or almost always, precedes the outcome, we

have arguably come a long way in terms of arriving at a general understanding of and explanation to such a social process compared to where we are today. Until now, we have not been able to provide evidence of such sequences at all across time and a large number of units, other than by individual case analysis found for example in historical sociology and in-depth case-study approaches.

4. Data

To explore the temporal relationship between various aspects of democracy utilizing the proposed sequence analysis approach, we use the V-Dem dataset v6 for the purposes of presenting. V-Dem aims to achieve transparency, precision, and realistic estimates of uncertainty with respect to each data point. The v6 dataset includes 173 sovereign or semi-sovereign states from 1900 to 2012, and data covering 2013–2014 for 60 of these countries.²

The indicators in the “V-Dem Codebook” fall into three main categories: 1) factual data gathered from other datasets or original sources; 2) evaluative indicators coded by multiple country experts; and 3) aggregated indices constructed by combining several indicators that load on the same dimension based on factor analysis results. The evaluative indicators are produced according to a complex and demanding protocol. Typically, five or more independent country experts code each country-year for each indicator and almost three thousand experts have been involved in the coding to date.³ To arrive at the best possible estimates, V-Dem has a team of measurement experts and methodologists who have developed an advanced Bayesian ordinal IRT-model for aggregating and weighting expert ratings and for calculating confidence intervals alongside a series of validity and reliability tests, including tests of intercoder reliability (see Pemstein *et al* 2015 and Coppedge *et al* 2015c). This model takes into account the possibilities that experts may make mistakes and have different scales in mind when providing judgments⁴. Indicators in V-Dem are mostly on an ordinal scale from 0 to 4 (originally, the dataset also

² A detailed explanation of the V-Dem approach can be found on V-Dem’s website, <https://v-dem.net>, along with the other V-Dem documents cited in this paper.

³ The coders’ considerable knowledge derives from a combination of experience and education: Most have lived in their countries of expertise for nearly thirty years, and 60 percent are nationals of that country. In addition, 90 percent have postgraduate degrees. Ratings accorded to a country are therefore largely the product of in-country expert judgments. In addition to providing a rating on each indicator, country experts also assign a “confidence score” (0 to 100), which measures how certain we can be about the rating. In addition, roughly a fifth of the coders undertake cross-country coding, making it possible for us to calibrate measurements between countries.

⁴ Simulations and other computational tasks to produce the V-Dem dataset was done using resources provided by the Notre Dame Center for Research Computing (CRC) through the High Performance Computing section and the Swedish National Infrastructure for Computing (SNIC) at the National Supercomputer Centre in Sweden. We specifically acknowledge the assistance of In-Saeng Suh at CRC and Johan Raber at SNIC in facilitating our use of their respective systems.

provides other versions). For indices where the original V-Dem scale runs from 0 to 1 has been transformed to ordinal categories ranging from 0 to 4, created and validated by Lindberg (2015) in order to enable the sequence analysis we are aiming for here. Note, however, that the analysis does not require an equal number of steps in the ordinal values utilized, although it does make interpretation easier. If there are an unequal number of steps, then variables can be standardized, or results interpreted ‘as is’.

5. The New Method: Sequential Requisites’ Analysis

To explore whether certain states of one variable are systematically conditional on certain states of other variables in existing data, we here extended the method termed ‘dependency analysis’ from an earlier paper (Lindenfors et al. 2015). The method is inspired primarily by “the contingent states test,” which is an established method developed to investigate historical sequences in biological evolution (Sillén-Tullberg 1993), with reasoning particularly well suited to use on sequence data outside biology. It also has some similarities with qualitative comparative analysis (QCA) (Ragin 1987; Rihoux & Ragin 2009) – indeed, in some sense it can be viewed as a modification thereof. Note that even though variables may co-vary the proposed method checks for requisites in the data, not statistical correlations. This is an important distinction since if and when one can establish such requisites – assuming that the data is more or less complete in coverage – this is evidence actual historical sequences realized in the data.

To conduct this type of dependency analyses, for each state of one variable, scan the dataset for the lowest state in all other variables. If higher states in one variable always correspond to higher “lowest states” in the other variables, then it can be inferred that certain states of that variable are likely to have been conditional on certain states of the other variables. If, on the other hand, for each state of the variable, the corresponding “lowest state” in the other variables are at their minimum, then this shows that change in the focal variable is not restricted by the other variables. These observations in combination indicate that potential dependencies between the variables exist only in one direction. Requisite should not be taken here as a causal relation, but as a description of historical observations: certain values for a certain focal variable have been conditional on certain values for the others. To allow some margin of error, a percentile of observations can be specified and treated as the “lowest values,” which will slightly relax the criterion of absolute dependencies. We here report dependencies allowing such a 95% “wiggle room,” following the convention in QCA.

Table 1 shows an example of the described procedure. The table indicates that the highest state of some variables occur *only* together with higher values in the others. This means, for

example, that “Legislature investigates in practice” only exists in its highest state if “Health Equality” is at least 2, “Election free and fair” is at least 4, and all the others are at least 3. On the other hand, the “Elected executive index” occurs in its highest state regardless of the values of the others, with the exception that “Access to justice for women” is at least 1. The sums listed in the right column indicates the sums of requisites from the highest to lowest. The sums listed in the bottom row indicates the sum of states that the other variables are dependent on. Thus, the order bottom to top indicate a sequence where the top variables are more dependent on reformed states of the bottom variables. Likewise, the order left to right indicate a sequence of dependencies where variables are more contingent on reformed states of the rightmost variables. The two lists, row and column, will be similar by necessity, but need not be identical. Note that the row and column sums need not depend on dependencies of the same variables, so some care has to be taken in interpreting these sums when comparing variables – variables can be compared, if that is deemed desirable, is through the use of Euclidean distance between requisite rows. Note also that the method is descriptive rather than hypothesis testing, so no significance values are reported.

Table 1:

Example of dependency table for the highest state of each variable. The highest state of the variables listed in the left column have not occurred in the data if the state indicated by the numbers in the table were not reached for each variable listed in the top row. For example, the variable “Legislature investigates in practice” has only been observed to exist in its highest state if “Health Equality” was at least 2, “Election free and fair” at least 4, and all the others at least 3.

	Health equality	High court independence	Legislature investigates in practice	CSO entry and exit	Harassment of journalists	Access to justice for women	Executive bribery and corrupt exchanges	Election free and fair	Sums
Legislature investigates in practice	2	3		3	3	3	3	4	21
Access to justice for women	2	2	2	3	3		2	4	18
High court independence	1		2	3	2	3	2	4	17
Harassment of journalists	0	1	2	2		2	3	4	14
CSO entry and exit	1	1	1		2	2	1	3	11
Election free and fair	1	1	1	1	1	1	1		7
Executive bribery and corrupt exchanges	0	0	0	0	1	1		3	5
Health equality		0	0	0	0	1	1	0	2
Sums	7	8	8	12	12	13	13	22	

From Table 1, it may seem that improvements in the rightmost variables are *necessary* conditions for improvements in the top variables. However, as the observed relationship is historical rather than causal, one should be careful implying a direct causal relationship (see e.g. Paine 2016; Thiem et al. 2016; Schneider 2016). A low number of dependencies for all states of a variable, though, indicates that there are very few necessary conditions for it to assume higher states – this can be stated firmly. However, the converse claim of causality is less supported. If a variable has a high number of requisites, this indicates that it historically never has reached higher states before a number of other variables have reached high levels, but any causal claim has to be made very carefully.

Table 2:

Example of dependency table for the all states of each variable. The state indicated of the variables listed in the left column have not occurred if the states indicated by the numbers in the table were not reached for each variable listed in the top row. For example, state 3 of the variable “Harassment of journalists” has only been observed to exist if “Election free and fair” was at least 2 and all other variables at least 1.

	Health equality	Legislature investigates in practice	High court independence	CSO entry and exit	Executive bribery and corrupt exchanges	Harassment of journalists	Access to justice for women	Election free and fair	Sums
Legislature investigates in practice 4	2		3	3	3	3	3	4	21
Access to justice for women 4	2	2	2	3	2	3		4	18
High court independence 4	1	2		3	2	2	3	4	17
Harassment of journalists 4	0	2	1	2	3		2	4	14
CSO entry and exit 4	1	1	1		1	2	2	3	11
Harassment of journalists 3	0	1	1	1	1		1	2	7
Election free and fair 4	1	1	1	1	1	1	1		7
Legislature investigates in practice 3	0		1	1	1	1	1	1	6
Executive bribery and corrupt exchanges 4	0	0	0	0		1	1	3	5
CSO entry and exit 3	0	0	1		0	1	1	1	4
Access to justice for women 3	0	0	1	0	0	1		1	3
High court independence 3	0	0		0	1	0	1	1	3
Harassment of journalists 2	0	0	0	1	0		1	0	2
Election free and fair 3	0	0	0	0	0	1	1		2
Election free and fair 2	0	0	1	0	0	0	1		2
Legislature investigates in practice 2	0		0	0	0	0	1	1	2
Health equality 4		0	0	0	1	0	1	0	2
CSO entry and exit 2	0	0	0		0	0	1	0	1
Legislature investigates in practice 1	0		0	0	0	0	1	0	1
Health equality 3		0	0	0	0	0	1	0	1
Health equality 2		0	0	0	0	0	1	0	1
Sums	7	9	13	15	16	16	25	29	
Harassment of journalists 1	0	0	0	0	0		0	0	0
CSO entry and exit 1	0	0	0		0	0	0	0	0
Election free and fair 1	0	0	0	0	0	0	0		0
Access to justice for women 1-2	0	0	0	0	0	0		0	0
High court independence 1-2	0	0		0	0	0	0	0	0
Health equality 1		0	0	0	0	0	0	0	0
Executive bribery and corrupt exchanges 1-3	0	0	0	0		0	0	0	0

For an analysis of sequential relationships between a larger number of states in all variables, a dependency table can be constructed for all possible combinations of states of the variables, and summarized. We here present a larger table indicating the order of all states in the

variables (Table 2). Thus, we can get a good sense of which variables come first, middle, and last in processes. This example of looking at the state-dependencies is of particular interest when one is analyzing for example what conditional relationships look like for achieving democratization.

The proposed method can be made to fail through analyzing variables with very skewed distributions, for example if all observed states for one variable are in the same state, or very few exceptions exist. Misleading results can also be the product of analyses where there are very few observations in total.

Conclusions

This paper details a new approach to the study of sequences in ordinal data in social science: requisite tables. The usefulness of this analytic tool is illustrated with a simple sequence analysis of eight ordinal values from the V-Dem electoral Democracy index (as per the v6 of the V-Dem dataset). We believe this approach has great potential for the analysis of many types of pressing issues that social science confronts, not the least the sequences of democratization. We hope to use this method in the near future to be able to answer critical questions of successful and unsuccessful sequences, as well as what democracy support should focus on at various stages of democratization in ways that can directly inform policy and practitioners' priorities.

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